

V. V. STREL'TSOV — THE FOUNDER OF THE SOVIET
SCHOOL OF AVIATION-SPACE MEDICINE

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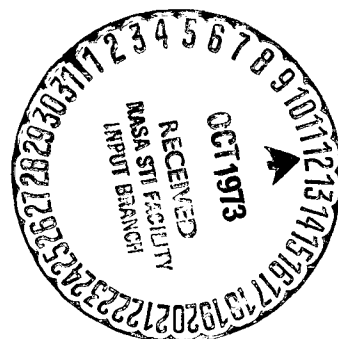
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V. V. STREL'TSOV — THE FOUNDER OF THE SOVIET SCHOOL OF AVIATION-SPACE MEDICINE

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The Sources of Aviation Medicine

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Among the glorious constellation of scientists who have made invaluable contributions to the inception and development of Soviet aviation and space physiology, a special place is justifiably occupied by Vladimir Vladimirovich Strel'tsov.

V. V. Strel'tsov entered aviation medicine in 1930 and it is extremely symbolic that it is in fact the 1930s which one can name as the period of blossoming of Soviet aviation medicine.

The initial date of the birth of Russian aviation medicine is accepted to be 14 July 1909, when at a meeting of the Council of the All-Russian Aero Club first organized in our country, a decision was made to "recognize the necessity of

permitting desirous members of the Aero Club to make flights only under conditions of their medical

Nikolay Aleksandrovich Agadzhanyan, Doctor of Medical Sciences, Chief of the Laboratory of the Institute of Medical-Biological Problems of the Ministry of Public Health of the USSR. His primary investigations have been devoted to the physiological aspects of the effect of high and low concentrations of oxygen and carbon dioxide on the organism, and to the physiological basis and principles of normalizing the atmosphere in hermetically sealed chambers, as well as to the problem of biological rhythms. In addition to scientific studies in the field of high altitude physiology, he has published several scientific-popular books including:

Biologicheskiye Ritmy [Biological Rhythms], Moscow, 1967; *Chelovek Atmosfera i Solntse* [Man, the Atmosphere and the Sun], Moscow, 1968; *Meditcina i Kosmos* [Medicine in Space], Moscow, 1971.

*Numbers in the margin indicate pagination in the foreign text.

permitting desirous members of the Aero Club to make flights only under conditions of their medical examination".¹

In approximately these same years, aviation medicine appeared in France and Germany, and only significantly later (1917-1919) in England, Italy and the United States. At all these stages of inception and development, aviation medicine was located in direct and intimate dependence upon the successes of aviation technology.

The first World War, having revealed the role and significance of aviation in the combat situation, made possible the vast development of aviation in many countries. If at the beginning of the war, even in the most developed of the capitalist countries, there were only a few dozen aircraft, in 1918, in such countries as France, England, Germany and the United States their quantity had reached tens of thousands.

In the postwar years, in France, the first pressure chamber and centrifuge specially built for investigating the influence of high altitude factors and accelerations on the pilot's organism were built and set up. In Germany, the first Institute of Aviation Medicine in the world was organized, having a well-equipped pressure chamber. English scientists extremely fruitfully summarized the materials of high mountain scientific expeditions and long term pressure chamber experiments. In Italy, the monograph "Physiology and Aviation" was published. In the United States, in 1925, the first manual on aviation was published, which in 1927 was translated into the Russian language. All of this made possible the formation of aviation medicine as an independent scientific discipline.

In this case, the fact that the theory and foundation of aviation medicine was based on the achievements of general physiology, and, specifically, on the classical investigations of P. Behr, I. M. Sechenov, G. Barcroft, G. Haldane, etc., deserves attention.

With the beginning of the first World War, studies in the field of aviation medicine in our country were stopped, not having succeeded, essentially, in

¹Cited according to the book: A. A. Sergeyev, *Ocherki po Istorii Aviatsionnoy Meditsiny* [Outlines on the History of Aviation Medicine], Moscow, 1962, p. 28.

being completely set up. And only following the great October Socialist Revolution did the true development of Soviet aviation begin, and together with it, Soviet aviation medicine. As early as the period from 1920 through 1926, in our country, there was more than a fourfold increase in the number of aircraft. Records established the fact that long flights were made, for example, in the summer of 1925 from Moscow to Peking (6,500 km), and in June of 1926 — from Moscow to Teheran and back (6,200 km).

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I. P. Pavlov With His Co-Workers and Fellow Scientists. Seated from right to left: fourth, I. P. Pavlov; fifth, L. A. Orbeli; standing in the back row, from right to left: fourth, A. V. Lebedinskiy; fifth, Ye. M. Krets; sixth, V. V. Strel'tsov. Photograph taken in 1927.

These flights, as was the case with the development of aviation as a whole, set before aviation physicians a number of very important physiological-hygienic problems requiring immediate solution. However the development of these

problems began extremely timidly, and it was only in the 1930s that the development of Soviet aviation medicine on a strictly scientific basis achieved a high level. This was to a great extent made possible by the arrival in the field of aviation medicine of talented young physicians.

Vladimir Vladimirovich Strel'tsov was a star of the first magnitude among them; with a great deal of effort and an astonishing working capacity, he began to work out medical problems of flights aboard aircraft and showed himself true to aviation medicine to the end of his life.

First, First, First...

In 1930, at the Institute of the Civil Air Fleet, a scientific research aeroinstitute was created. Among the 12 sections which comprised the institute, there was also a section of aviation medicine which was headed up by A. A. Sergeyev. The scientific fellows of this section were V. V. Strel'tsov, P. I. Yegorov, A. S. Aleksandrov, K. L. Khilov, A. V. Lebedinskiy, N. V. Zimkin and others. All of them came from the S. M. Kirov Military-Medical Academy and were outstandingly prepared both theoretically and methodologically and at an accelerated pace involved themselves in the development of a new scientific trend.

In the section of aviation medicine, V. V. Strel'tsov worked, in all, for a year and a half and deeply became interested in problems of aviation medicine. At the end of 1931 he was transferred to Moscow and made Chief of the 4th sector of SRSI (Scientific-Research Sanitary Institute).

At that time, in aviation medicine, there was a widespread psychophysiological trend which was unjustified, and in order to approach the development of scientifically founded measures for ensuring safety of high altitude flights it was necessary to make a fundamental breakthrough in scientific work. And V. V. Strel'tsov made this breakthrough; he headed an entirely new and exceptionally fruitful trend in Soviet aviation physiology.

V. V. Strel'tsov was at the zenith of his creative strength and although he was not yet 30 years old, he was one of the most talented students of L. A. Orbeli — he already had an excellent experimental technique and had received an outstanding physiological education; he was not only acquainted with and

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attentively interested in basic problems of aviation medicine, but he was also deeply cognizant of the necessity for comprehensively expanding and developing his own trend in this field. In connection with the mastery of the upper layers of the atmosphere and increasing distance of flights in this period, the attention of aviation physicians was directed primarily to questions of high altitude physiology. Being a classical physiologist, V. V. Strel'tsov, during his development of this problem, from the very onset structured his work, basing himself on progressive positions of Soviet physiology which at that time were headed up by I. P. Pavlov.

It is entirely obvious that for a successful development of a new scientific trend good personnel were needed and a good material supply of equipment for the laboratory. V. V. Strel'tsov gathered about him remarkable cadre. At first the basic personnel were V. V. Strel'tsov and A. P. Apollonov, V. G. Mirolyubov, N. A. Vishnevskiy and I. K. Sobennikov. With respect to material equipment, matters were somewhat worse. It is adequate to note that only in these years, at last, was the first pressure chamber assembled in the Soviet Union, opening up an entire epoch in Soviet aviation medicine.

It was in fact V. V. Strel'tsov who first understood the problem of the necessity of building a pressure chamber in our country and who expressed the idea of the efficiency of training pilots in the pressure chamber in order to increase their high altitude resistance. Today, when scientific laboratories and scientific research centers are not only in Moscow and Leningrad, but also in many other cities of the Soviet Union are equipped with modern pressure chambers and powerful thermovacuum installations, it is hard to imagine for oneself that there was a time when our country did not have a pressure chamber...

This is what A. A. Sergeyev writes on this subject in his "outline": "This was the pressure chamber in which, on 29 August 1932, V. V. Strel'tsov was the first person in the USSR to "ascend" to an altitude of 13,000 m. This was the pressure chamber, working with which V. V. Strel'tsov, in 1932, first reported the possibility of preliminary adaptation to increase the high altitude tolerance of the pilot. This was the pressure chamber in which A. P. Apollonov succeeded in accomplishing the first test of Soviet oxygen equipment in the USSR.

Finally, this was the pressure chamber which enabled A. P. Apollonov and V. G. Mirolubov to develop and produce the first data on high altitude flights and on their medical support".² Pay attention to how many times one hears the word "first"...

But where is this pressure chamber? Today this "workhorse", which covered itself with glory together with V. V. Strel'tsov in the matter of Soviet aviation medicine, is located in one of the storerooms for obsolete equipment. And more's the pity. It deserves to be a valuable exhibit, to be placed in the Museum of Aviation and Astronautics together with the first Soviet aircraft and spacecraft.

Aviation medicine developed simultaneously with the vast development of Soviet aviation. In fact in the 1930s, Soviet pilots and Soviet aircraft made a number of world record distance flights without landing (M. M. Gromov), for altitude (V. K. Kokkiniki), and for length of flight in a straight line (V. P. Chkalov, G. F. Baydukov, A. V. Belyakov). An adequate contribution to the preparation and support of these flights was made by representatives of aviation medicine, primarily in the person of V. V. Strel'tsov and his co-workers, who had the problems of medical support and safety of altitude in long distance flights placed upon them.

In connection with the development of high altitude aviation it was particularly important to obtain experimental foundations in response to two questions, which for that time had principally important practical significance, namely: the individual altitude ceiling and capacity to increase resistance of the organism to the effects of high altitude factors. For obtaining an answer to these questions, V. V. Strel'tsov and his co-workers not only carried out a vast amount of experimental work, but also by their authority attracted attention to these problems on the part of many Soviet aviation physiologists.

V. V. Strel'tsov developed concrete scientifically founded prophylactic measures directed toward increasing the work capacity of the pilot and for ensuring the safety of high altitude flights. The useful results obtained by

²A. A. Sergeyev, *Ocherki po Istorii Aviatsionnoy Meditsiny* [Outlines on the History of Aviation Medicine], Moscow-Leningrad, 1962, p. 92.

V. V. Strel'tsov by means of pressure chamber conditioning of pilots and by means of their deep physiological foundation enabled inclusion of the pressure chamber conditioning in the standard program for altitude training of pilots. Thanks to this and to the personal initiative of V. V. Strel'tsov, mass production of pressure chambers in the USSR began and they were used to equip the large airfields of our country.

In 1932, the Central Psychophysiological Laboratory for the study of flight work was set up. In 1935, with the arrival of V. V. Strel'tsov to assume the duties of laboratory chief, it began to live a full-bodied creative life. In the period 1936-1939, seven volumes of the laboratories collected works were published. All of their experimental data in the field of physiology of altitude and high velocity flights were formed by V. V. Strel'tsov, in 1938, into a doctors dissertation on the subject "The Influence of Decreased Barometric Pressure and Accelerations on the Organism". One is obliged to rue the fact that up to this time this fundamental work of this remarkable scientist has not been published in the form of a monograph.

The vast scientific research activity of V. V. Strel'tsov was combined with a no less active scientific-organizational and social work. V. V. Strel'tsov first posed the question of the necessity of special training of physicians for aviation.

Having headed up the organization of the department of aviation medicine of the Central Institute for Advanced Physician's Training and at the second Moscow Medical Institute, with his active participation, V. V. Strel'tsov applied vast efforts to selecting teachers and to setting up the first programs and training-methodological aids as well as to the acquisition of laboratory equipment and installing a pressure chamber. Simultaneously with this, V. V. Strel'tsov, in the period 1940-1942, published a number of studies, primarily on the subject of high altitude physiology. In his work "Concerning the Nature of High Altitude Illnesses Appearing in Pilots During High Altitude Flights" (1940), V. V. Strel'tsov poses a number of important concepts concerning the reasons for decompression illness [Translator's Note: bends]. He concludes that altitude diseases at the indicated altitudes are encountered in 7% of the cases and that preliminary oxygen breathing for a period ranging from 20 minutes

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to 3 hours does not produce favorable results. These data gave him bases to hypothesize that the reason for appearance of altitude diseases should be sought not only in the presence of nitrogen in the organism. In his opinion, the appearance of decompression phenomena include a certain role which can be played by other factors as well, such as increased tension in the capsules of the joints and ligaments, causing irritation of the nerve endings; disruption of osmotic pressure in the synovial fluid; cold irritation of the joints; isothermic and adiabatic process of gas expansion; the aggravation of sensitivity to pain and certain others. In this period he had still not made categorical judgements concerning the predominant role of an particular etiological factor, but only has indicated the necessity of conducting further and deeper investigations. At the present time, in connection with the intensive development of aviation and cosmonautics, and with man's entry into outer space this problem has become one of the most pressing and many scientific institutes in our country and abroad are participating in its development.

In speaking of the investigations of V. V. Strel'tsov in wartime, it is particularly necessary to emphasize that it was in fact during this period that he first, not only in Soviet, but also in world science raised the question of the possibility of appearance of conditioned reflexes by means of the same disorders which developed during elevation to an altitude in the pressure chamber. Studying changes in the kidney function, and namely: the quantity and specific gravity of the urine, the presence of bicarbonates, the acid-base equilibrium, the content of ammonium, phosphorus and organic acids, he demonstrated that following 3 to 4 actual ascents of the subject to an altitude, the mere simulation of altitude caused monotypically directed changes in the renal functions. After 7 to 9 simulated ascents, the indicated conditioned reflexive reactions diminished but it was necessary to conduct yet another actual ascent, and as soon as this occurred the diminished temporary links were once again fully established. Hence, V. V. Strel'tsov, having established the capacity for the appearance of hypoxic conditioned reflexive reactions, first experimentally demonstrated the leading role of the cerebral cortex in adaptation of the organism to high altitude factors,



Vladimir Vladimirovich Strel'tsov. 26 June 1902 — 1 July 1947. Photograph 1935.

During the war, the attention of V. V. Strel'tsov was redirected toward compiling a number of brochures ("In the Assistance of the Aviation Physician") on the influence of altitude and accelerations on the pilot's organism. These brochures, written by such an authoritative researcher, were extremely vital to the aviation physicians.

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Examining the influence of various unfavorable factors on the organism from the position of evolutionary physiology, specifically, the factor of oxygen starvation, V. V. Strel'tsov based his work on the fact that under these conditions, primarily, those physiological functions, those structures of the brain must suffer which in the process of phylogenetic development appeared last. He wrote: "The brain is the organ most sensitive to oxygen deficiency. Even with a very slight decrease in oxygen in the inspired air, functional disorders in the activity of the brain first begin and then worsen. Thought becomes less clear. Decisions are made with a long lag time. There is an increase in the number of erroneous actions. Motions are neither accurate nor coordinated. There is a gradual decrease in the critical estimation of reality. In the subjective state, the self estimation is that one is quite well".³

Taking into account the fact that various regions of the central nervous system developed at various periods of phylogenesis, the reactions of these regions to oxygen starvation should occur in a certain sequence strictly corresponding to the sequence of phylogenetic development of these regions. This is what V. V. Strel'tsov wrote on the subject: "The onset of a number of pathological reflexes characteristic of the subcortex and which appear in case of blockage of the cortical impulses also indicate that in the deep stages of development of anoxemia there is a dissociation between the cortical and subcortical impulses. Whether or not in the cases there is a disruption in the synaptic links or whether the nerve cells are primarily damaged is yet difficult to comment on at this time... In the central nervous system a complex process of disruption of the functions of the central representations of sensitivity occurs with disruption in the balance of processes of inhibition and stimulation, which causes a sharp turnabout in behavioral reactions and which is the reason for the onset of convulsions and an increase in tremor.

³V. V. Strel'tsov, *Vysotnyye Polety i Vliyaniye ikh na Organizm Cheloveka* [High Altitude Flights and Their Influence on the Human Organism], Moscow, 1939, p. 30.

All of this, taken together *in toto*, also lies at the basis of the deep disorders in psychic activity of man and causes inadequacy of behavior."⁴

The experimental verification of this concept of V. V. Strel'tsov was one to which he devoted many years. Although the fact of early disorders of a number of mental functions at high altitudes was known even in the last century, it was only the comprehensive experiments of V. V. Strel'tsov and his co-workers, however, coupled with their use of a combination of various methods which made it possible deeply and integrally to understand the mechanism of physiological disorders which appear under conditions of rarefied atmosphere. During this process V. V. Strel'tsov was not a collector and archivist for facts: he not only factually thought out the idea of the experiments, not only carefully analyzed them, but he also broadly interpreted and summarized the obtained results.

The materials of the experimental investigations enabled V. V. Strel'tsov to form a number of most important and original conclusions for that time. V. V. Strel'tsov indicates that under conditions of a rarefied atmosphere a "gradual and very delicate layer by layer shutdown of the brain occurs, beginning with the uppermost layers of the cortex and extending to the subcortical ganglia", being, as it were, a "functional decerebration." "At certain stages in the development of altitude disease (phenomena of anoxic anoxemia), disorders of the functions of the central nervous system begin in a very clearcut fashion which are very much analogous to phenomena of alcohol poisoning. They are characterized by a state of euphoria, acts based on poor judgement, disorders in the coordination of motion and in certain cases by total retrograde amnesia. The phenomena of oxygen starvation and alcohol poisoning are to a great extent identical: both, primarily, "accumulate", being directed toward the cerebral cortex. We have also "foreseen" the systematic attack of the brain, penetrating into it along the afferent systems."⁵ It is not by accident that many

⁴V. V. Strel'tsov, "The Influence of Forces of Acceleration and Low Barometric Pressure on the Organism," *Voyenno-sanitarnoye Delo*, No. 1, p. 17, 1939.

⁵V. V. Strel'tsov, "The Influence of Forces of Acceleration and Low Barometric Pressure on the Organism," *Voyenno-sanitarnoye Delo*, No. 1, p. 15, 1939.

scientists working the field of altitude physiology quite successfully and correctly compare the phenomena of oxygen starvation with the symptoms of alcohol poisoning.

A great deal of V. V. Strel'tsov's attention was given a study of the analyzer function. Studying the functions of sight under conditions of a rarefied atmosphere enabled V. V. Strel'tsov to conclude that these disorders primarily depend upon damage to the cortical representatives of the visual analyzer.

Somewhat later (1942), V. V. Strel'tsov, in one of his studies conducted jointly with A. A. Dorodnitsyna, makes an attempt to reveal the mechanism of altered light sensitivity of the eyes at an altitude of 5,000 m. He concludes that during exposure to oxygen starvation, primarily, the "ordinary interactions and interrelationships in the central representatives of the retina are disrupted". In a number of studies he attempts by the aid of pharmacological substances to preserve a high level of functioning of the visual analyzer.

In addition to studying the functions of the visual analyzer, V. V. Strel'tsov also conducted experiments (together with I. S. Nechayeva) on studying the functions of the receptors of the vestibular nerve, for purposes of investigating it, he primarily applied the method of chronaxsymmetry. It was noted that at altitudes of 8-10,000 m one observed a decrease in the responsiveness of the vestibular apparatus.

Hypoxia and Hypercapnia

The first experimental investigations of V. V. Strel'tsov were devoted to the physiology of altitude flights. In these studies (1933), V. V. Strel'tsov not only comprehensively cast light on the nature of the question concerning changes in the gaseous composition and tension of blood gases during elevation to an altitude, but also, on the basis of his own data, expresses his original viewpoints on the problem under study and indicates paths of practically applying the results.

The experimental material obtained by V. V. Strel'tsov has not lost its usefulness even up to the present day. As is known, the complex influence on the organism of oxygen deficiency and surplus carbon dioxide gas has an

extremely complex character. An increase in the content of CO_2 in the inspired atmosphere causes, against a background of hypoxia (oxygen starvation) a more significant increase in the minute volume of respiration. The total ventilation reaction to hypoxia in combination with hypercapnia (increased partial pressure of carbon dioxide) exceeds the arithmetical total of the effects of these factors acting singly. In the opinion of V. V. Strel'tsov, an increase in the content of CO_2 prevents harmful consequences of hypocapnia (decreased partial pressure of carbon dioxide), which develops under conditions of increased pulmonary ventilation during hypoxia. A certain level of CO_2 in the internal medium is an unalterable condition for ensuring that the organism reacts totally to the hypoxic stimuli.

The pronounced compensative reactions of the organism observable in the initial period of staying in the hypoxic-hypercapnic atmosphere are achieved at too high a price and are primarily related to large energy expenditures on intensive hyperventilation (an increase in the frequency in minute volume of respiration).

Expenditures of energy particularly sharply increase with a carbon dioxide content in the inspired air above 5%. Adding CO_2 to the hypoxic atmosphere little increases the delivery of oxygen to the tissues. Extreme hypoxia (less than 8% O_2) cannot increase, but, on the other hand, suppresses the ventilator reaction to CO_2 , while high concentrations of CO_2 (over 6%) cause diminution or even disappearance of the respiratory reaction to hypoxia. V. V. Strel'tsov indicated that at high altitudes, during the organisms' exposure to acute oxygen deficiency, adding carbon dioxide worsens the condition of the organism, since under similar conditions the debit of oxygen is much higher than is that of carbon dioxide.

Hence, during short time exposure to hypoxia adding CO_2 (up to 3%) can yet be justified, a fact which pertains to long term stay of man in an artificial hypoxic-hypercapnic atmosphere, and there is every basis to expect an unfavorable influence of such an atmosphere in connection with overall suppression of the compensator adaptive reactions of the organism.



V. V. Strel'tsov in the First Soviet Pressure Chamber. In this pressure chamber, on 29 August 1932, V. V. Strel'tsov was the first person in the Soviet Union to "ascend" to an altitude of 13,000 m. Photograph 1932.

Applying the results of his investigations to a study of the influence of breathing gas mixtures on the organism of man, V. V. Strel'tsov does not make final conclusions concerning the effectiveness of breathing such mixtures.

In connection with the appearance in the 1930s of ideas of creating in the USSR a stratospheric balloon, aviation medicine and primarily the collective of V. V. Strel'tsov were faced with the solution of a number of other biomedical problems. The basic task pertained to supporting the physiological conditions of existence of people in a hermetically sealed chamber of limited volume. It was necessary primarily to clarify the principles of an increase of CO_2 and a decrease of O_2 during a long term stay of a man in the hermetically sealed enclosure.

The fact of the matter was that it is not only in habitable cabins of aircraft, stratospheric balloons and spacecraft, but also in the space cabins of submarines, and spacesuits during a man's presence in them that an accumulation of carbon dioxide occurs accompanied by a decrease in the oxygen content and thus constant regeneration of the atmosphere is an important and, at that time, was an extremely complex scientific-practical problem. Designers and physician- /56-physiologists had to foresee the possible cases of breakdowns of regenerating devices and explain the maximal permissible concentrations of oxygen and carbon dioxide, as well as develop recommendation directed toward increasing the resistance of the organism during a long term stay under conditions of an altered atmosphere with an increased carbon dioxide content.

For a long time carbon dioxide was considered only the terminal product of metabolism, a harmful product which it was desirable to remove from the organism. Investigations of V. V. Strel'tsov and his co-workers, based on fundamental experimental data, enabled them to establish the role of carbon dioxide in oxygen transport and to reveal the biological significance of the fine and fine regulation of the level of carbon dioxide in the blood, which exists in the organism.

The many experiments conducted by V. V. Strel'tsov in the pressure chamber (including experiments which he conducted on himself), specifically yielded a basis to recommend for normal oxygen supply of flights, and for the removal of CO_2 , placing a Dewar vessel in the gondola of the stratospheric balloon, containing 3 liters liquid O_2 and cartridges containing a chemical carbon dioxide absorbant. The correctness of solution of many medical questions on supporting the flight of the stratospheric balloon was shown by the successful flight of the stratospheric balloon "USSR" on 30 September 1933 to an altitude of 18.6 thousand meters. The studies conducted under the supervision and with the direct and creative participation of V. V. Strel'tsov had important significance not only for ensuring the safety of high altitude flights, but also for the further development of aviation and space medicine in our country.

Being based on the fundamental investigations of V. V. Strel'tsov and his students, Soviet scientists are continuing successfully to work our biomedical problems of flights of aircraft. Simulating conditions of breakdown

of life support systems, in our investigations we have shown that with an increase in the content of carbon dioxide in the chamber, at a rate of 3.5 mm Hg per hour, and with a simultaneous decrease in the partial pressure of oxygen at a rate of 4.7 mm Hg per hour, it is possible to have (over a course of 16-18 hours) a long term stay of man in a hermetically sealed chamber having a volume of 8 m³ under conditions of normal and diminished (4-5 mm Hg) pressure.

Factors of High Mountainous Environments

Although the pressure chamber investigations provided the basis for the theoretical development of problems of oxygen starvation and altitude adaptation, it did not follow, all the same, entirely to identify the physiological reactions observable in pressure chamber investigations with the reactions obtained during long term exposure to a complex of climatic factors of a high mountainous environment. In the latter case the organism is exposed to the influence not only of the decreased atmospheric pressure and the related decrease in partial pressure of oxygen, but also to an entire complex of other stimuli: sharp temperature fluctuations and humidity fluctuations in the environment, the rate of air movement, its ionization and electrical state, the high level of ultraviolet and infrared radiation, and finally, continental and relief characteristics of the terrain. The totality of all of these indicated factors determines the concept of the mountainous climate.

Having established in experiments the relatively low effectiveness of pressure chamber conditioning and of certain pharmacological substances in increasing resistance to hypoxia, V. V. Strel'tsov directed his attention to the necessity of studying the influence of the high mountainous climate on the human organism and on the organisms of animals. "In those cases," he wrote, "when the possibility exists to use the high mountainous climate for pilots with the goal of increasing their fighting capacity during high altitude flights, it is necessary to practice stationing them at special mountain camps and sending them on expeditions and excursions."⁶ Further, renewing this thought,

⁶V. V. Strel'tsov, "Prophylaxis of Hypoxemic Conditions in Aviation," *Klinicheskaya Meditsina*, No. 3, p. 17, 1941.

he emphasized: "At mountainous altitudes, changes in all of the physical-chemical constants occur in the organism which ensure optimal tissue supply of oxygen. Under conditions of elevations in the pressure chamber, man is only forced to be located under conditions of decreased barometric pressure for a few hours."⁷

It was in fact V. V. Strel'tsov who was first, in 1935, to raise the question of the necessity of creating high mountainous physiological stations, aircraft laboratories and microclimate chambers. The successful solution by V. V. Strel'tsov of many problems was made possible by the fact that he, in his scientific research, never became separated from aviation practice.

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V. V. Strel'tsov had the rare gift of rapidly orienting himself to the rapidly changing picture of the development of science, of foreseeing what could be the result of any particular discovery, and had the capacity to develop intended successes in more significant directions and to creatively participate in the development of ways of practically applying the results of his investigations. Being cognizant of his responsibility for the trend of work which he headed up, V. V. Strel'tsov worked tirelessly, self-sacrificingly and inspirationally, but did not hurry, did not attach himself to stylish fads. He followed his own short lifetime course, remaining to his last days a man whose name was writ in capitals, a respected and always trusted person, a direct fire brand, like a youth, but at the same time, like an all understanding prophet.

Without uttering pretentious speeches, without striving to use his unarguable authority to suppress anyone's independence, he was capable of pointing out to all the correct path and of doing this with surprising tact.

V. V. Strel'tsov was not only one of the creators of Soviet aviation medicine: he advanced those progressive ideas which then educated a generation of scientists, and raised to the present height Soviet aviation and space medicine. About him one can speak in the words of Goethe: "He who was a good

⁷Ibid, p. 21.

citizen of his time he has the most basis to be the contemporary of all times in the future".

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